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## THE HYDROCARBONS OF UTAH<sup>1</sup>

By CARLOS BARDWELL, B. ARTHUR BERRYMAN, THOMAS B. BRIGHTON  
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About fifteen kinds of hydrocarbons occur in Utah; the five of these occurring most abundantly—gilsonite, tabbyite, wurtzilite, ozocerite and rock asphalt—are the ones selected for this investigation.

Gilsonite<sup>2</sup> (uintaite) was first described by Blake in 1885. He gave it the name uintaite because of its occurrence in the Uinta Mountains. Later the name gilsonite was adopted because S. H. Gilson, a prospector, brought it into prominence as an article of commerce. The deposits of gilsonite are limited to the Uncompahgre Indian Reservation in Uinta County, being found in an area extending along the 40th parallel for about 60 miles.

Tabbyite receives its name from an Indian chieftain, Tabby. The deposits are in Tabby Canyon, a branch of the Duchesne, about 8 to 9 miles south and west of Theodore, Uinta County.

Wurtzilite<sup>3</sup> (elaterite or mineral rubber) from Utah was first described by Wurtz, who showed that it is a distinct mineral. The name elaterite had been used previously by Dana and other mineralogists to describe three different minerals of specific gravities ranging from 0.905 to 1.223. The region in which wurtzilite is found covers an area of about 100 square miles between Indian Canyon and Sam's Canyon, branches of Strawberry Creek, about 30 miles due north of Price, Utah.

Ozocerite (mineral wax) has been known for many years on account of the economic value of the large deposits in Galicia, Austria. The only other deposit known to be of commercial value is that in Utah. This deposit begins about two miles west of Colton, Utah County, and extends to about four miles west of Soldier Summit, a distance of 12 miles. The belt is 2 miles wide. This area may be divided into three parts:<sup>4</sup> (1) near Colton, on the north side of the

<sup>1</sup> This work was done at the suggestion and under the direction of Dr. W. C. Ebaugh, to whom the authors' thanks are due.

<sup>2</sup> Blake, *Eng. Min. J.*, 40, 431 (1885).

<sup>3</sup> Wurtz, *Ibid.*, 49, 59 (1890).

<sup>4</sup> Taff and Smith, U. S. Geol. Survey, *Bull.* 285, 369 (1905).

Price River valley; (2) to the east of Soldier Summit where the railroad crosses the crest of the plateau; and (3) near Midway Station, on the north side of the canyon, near the source of Soldier's Creek.

Heretofore rock asphalt has usually been called bituminous sandstone, but the former name is growing in popularity, especially in Utah. The largest deposit in the state lies south and east of Vernal, north of the White River and between Ashley and Uinta valleys.<sup>1</sup> This deposit attains a thickness (in places) of twenty feet, but at present it is too far from a railroad for successful commercial exploitation. Another deposit occurs in Spanish Fork Canyon, southeast of Thistle, and still other immense deposits are found (1) in the tributaries of Whitmore Canyon, near Sunnyside, (2) at the head of Willow Creek, a tributary of the Green River, in the Book Cliff Mountains, and (3) in the Laramie sandstones near Jensen, on the Green River. A deposit of bituminous *limestone* occurs at the head of the right-hand branch of Tie Fork, a canyon entering Spanish Fork Canyon, 2 miles west of Clear Creek Station. An area underlaid by bituminous limestone, about 50 miles long east and west by 10 miles wide north and south, lies just north of Colton and south of Strawberry Creek, extending from Antelope Creek on the east to Thistle on the west.<sup>2</sup>

#### HISTORICAL

In reviewing the literature of these substances one finds that a great deal has been published concerning gilsonite and ozocerite, but not much about wurtzilite, tabbyite and rock asphalt. Day,<sup>3</sup> working with gilsonite, attempted to isolate "such single hydrocarbons or their derivatives as would give some information as to the real nature of the mineral itself." He gives an outline of the physical characteristics, solubilities, etc., of gilsonite, and describes the character of the residue from each solvent as well as the nature of the dissolved portion. Proximate and ultimate analyses are given. From a study of the distillation products of gilsonite he concludes that the oil obtained belongs to the paraffin series of hydrocarbons, and is made up of a number of distinct substances, just as is petroleum. He obtained from the distillate volatile with steam, oils which seem to correspond to those described

<sup>1</sup> Wigglesworth, *Trans. Am. Inst. Min. Eng.*, **17**, 115 (1888).

<sup>2</sup> Eldridge, U. S. Geol. Survey, *17th Ann. Rept.*, **1896**, 915, *et seq.*; *22nd Ann. Rept.*, **1900-01**, 332.

<sup>3</sup> Day, *J. Frank. Inst.*, Sept., **1895**, 221, *et seq.*

by Peckham<sup>1</sup> as obtained from California bitumens. These had an odor similar to quinoline, and to him this was an evidence of the relationship of California bitumen and of gilsonite and of their animal origin. Day gives also the results of treatment with nitric acid and descriptions of the products and their properties, concluding that some members of the naphthalene series are present.

Eldridge<sup>2</sup> described the location of the hydrocarbon deposits and the geology of the district. He states that the cracks in which gilsonite is found were formed by the gentle folding that produced the Uinta Valley syncline. He describes the properties of the gilsonite coming from near the surface where, through atmospheric agencies, it has lost its luster and become pencilled in structure. From a study of conditions he concludes that the gilsonite found its way into the fissures as a plastic mass, coming from below under pressure, and though of high viscosity, sufficiently fluid to be pressed between the grains constituting the wall rocks. He frankly confesses his lack of ability to suggest the condition under which the gilsonite existed prior to its flow into the cracks. An analysis of gilsonite by Day is quoted as follows:

	Percentages
Volatile matter.....	56.46
Fixed carbon.....	43.43
Ash.....	0.10
or	
Carbon.....	88.30
Hydrogen.....	9.96
Sulfur.....	1.32
Ash.....	0.10
Oxygen and nitrogen (undetermined).....	0.32

Locke,<sup>3</sup> Blake,<sup>4</sup> Raymond,<sup>5</sup> and Wurtz<sup>6</sup> describe the uses of gilsonite, its solubilities, methods for "fluxing" it, etc. The earlier analyses of asphalts gave rather large percentages of oxygen, but this was probably because the presence of sulfur had not been recognized and the oxygen was supposed, with the carbon and the hydrogen, to make up the ash-free bitumen. Nevertheless some analyses which report sulfur and nitrogen also report small amounts of oxygen.<sup>7</sup> By some authorities, as Richardson and Peckham, oxygen is considered as foreign to natural asphalts.

<sup>1</sup> Peckham, *Am. J. Sci.*, **48**, III, 250.

<sup>2</sup> Eldridge, U. S. Geol. Survey, *22nd Ann. Rept.*, **1900-01**, 330.

<sup>3</sup> Locke, *Trans. Am. Inst. Min. Eng.*, **16**, 162 (1887).

<sup>4</sup> Blake, *Eng. Min. J.*, **40**, 431 (1885).

<sup>5</sup> Raymond, *Trans. Am. Inst. Min. Eng.*, **17**, 113 (1888).

<sup>6</sup> Wurtz, *Eng. Min. J.*, **48**, 114 (1889).

<sup>7</sup> Sadtler, *THIS JOURNAL*, **5**, 393 (1913).

In the first reference to wurtzilite, Blake<sup>1</sup> describes it from a physical standpoint, noting its occurrence, hardness, color, specific gravity, fusibility, electrical properties, etc. He explains the difference between wurtzilite and gilsonite,<sup>2</sup> and shows that the Utah wurtzilite is an entirely distinct mineral from the elaterite of Dana and other mineralogists. Wurtz<sup>3</sup> confirms the conclusions of Blake.

Utah ozocerite is very similar in properties to that from Galicia, but as it contains less oily material and is firmer, it is more valuable. Many popular accounts<sup>4</sup> of its mode of preparation, uses, etc., are to be found, but nothing concerning its chemical composition, distillation products, etc.

With the exception of occasional references to the location of bituminous sandstones in Utah, nothing could be found about rock asphalt.

#### USES OF UTAH HYDROCARBONS

An investigation of the uses of Utah hydrocarbons shows them to be surprisingly numerous and varied. Many of our commonest articles are made from these substances. Before the discovery of gilsonite in Utah, European and Asiatic asphalts were shipped into the United States; now, because of its abundance and purity large quantities of Utah asphalt are shipped to foreign countries. The production of gilsonite during the last two years has increased rapidly, due to the greater number of articles made from it. In 1910<sup>5</sup> the production was 30,000 tons; in 1912, over 50,000 tons. It is worth about \$20.00 a ton, f. o. b. Utah.

Wurtzilite is little used because of its insolubility. About 1,000 tons are produced annually.

Ozocerite is of greater value than gilsonite, the price in New York being 15 to 28 cents per pound.<sup>6</sup> No data could be found as to the production of ozocerite, but at present the demand far exceeds the supply.

Perhaps the most extended use that has been made of Utah asphalts is in the paving industry. Gilsonite has been used in paving the streets of many important cities,<sup>5</sup> e. g., Michigan Avenue, Chicago, where it is said to be giving satisfaction under the most exacting

<sup>1</sup> Blake *Eng. Min. J.*, **48**, 542 (1889).

<sup>2</sup> Blake, *Trans. Am. Inst. Min. Eng.*, **18**, 497 (1889).

<sup>3</sup> Wurtz, *Eng. Min. J.*, **49**, 106 (1890).

<sup>4</sup> Higgins, *Salt Lake Mining Review*, **14**, 11-5 (Oct., 1912). Culmer, *Salt Lake Tribune* (Dec. 29, 1912); Taff and Smith, U. S. Geol. Survey, *Bull.* **285**, 369 (1905).

<sup>5</sup> Culmer, Address, Univ. of Utah, Nov. 15, 1912.

<sup>6</sup> Higgins, *Salt Lake Min. Rev.*, **14**, 11-5 (Oct. 15, 1912).



requirements. Rock asphalt was used<sup>5</sup> in paving Second South Street between West Temple and First West Streets, Salt Lake City, and the surface is now in fair condition, although it has had practically no repairs during its 16 years of service.

Another important use for Utah hydrocarbons is in the manufacture of varnishes and paints.<sup>5</sup> Only the purest and best materials are used for these purposes, the refined hydrocarbons being dissolved in turpentine and linseed oils. Wurtzilite has been used in the manufacture of a varnish in which the particles are simply held in suspension, but do not enter into solution.

Some of the uses of the individual Utah hydrocarbons are as follows:

*Gilsonite*.<sup>1</sup>—Paving industry, electrical insulators, roofing papers and compounds, water-proofing wooden and steel pipes and masonry aqueducts, preventing electrolytic action on iron plates of ship bottoms, coating barb wire fencing, coating sea walls of brick or masonry, lining tanks for chemicals, coating poles, posts and ties, torpedo-proof pile coating, smokestack paint, lubricant for heavy machinery, substitute for rubber, as binder pitch for culm in making briquettes and egette coal.

*Tabbyite*.—Compounds with Para rubber to manufacture floor mats, rubber paints and roofings; as a filler for rubber in automobile tires, etc.

*Wurtzilite*.—Varnishes, roofing compound, etc.

*Ozocerite*.<sup>2</sup>—Electrical insulator (said to have about four times the specific resistance of paraffin), altar candles, substitute for beeswax, ointments, pomades, salves, water-proofing, waxed paper, wax dolls and figures, telephone receivers, phonograph records, electroplating, water-proof crayons, shoe polish, buttons, ceresine, floor polishes and waxes, water-proofing cartridges, sealing wax, etc.

*Rock Asphalt*.—Paving industry.

#### EXPERIMENTAL RESULTS

The results of the first tests made upon eight samples of hydrocarbons are given in Table I.<sup>3</sup> They are

<sup>1</sup> Locke, *Trans. Am. Inst. Min. Eng.*, **16**, 162 (1887); New Internatl. Encyc. Article on "Asphalt;" Culmer, *loc. cit.*; Richardson and Parker, U. S. Geol. Survey, *Min. Resources of U. S.*, **1893**, 627-69; Taff and Smith, U. S. Geol. Survey, *Bull.* **285**, 369 (1905).

<sup>2</sup> New Internatl. Encyc., Article on "Asphalt;" Higgins, *Salt Lake Min. Rev.*, **14**, 11-5 (Oct. 15, 1912).

<sup>3</sup> For purposes of comparison determinations were carried out also upon samples of refined Trinidad and Bermudez asphalt kindly supplied by the New York Testing Laboratory.

TABLE I

Original substance	Trin.	Ber.	Gils.	Tab.	Wur. 1	Wur. 2	Ozok.	R. A.
Loss 212° F., 1 hr., per cent.....	0.073	0.1765	0.353	0.91	0.53	0.21	0	0.14
Loss 325° F., 7 hrs., per cent.....	1.717	6.63	0.217	2.78	2.76	1.66	45.41	1.43
Penetration residue.....	0	30	0	0	0	0	15	0
New sample loss 400°, 7 hrs.....	5.25	9.71	0.85	6.40	3.88	1.88	65.20	1.79
Penetration residue.....	0	0	0	0	0	0	0	0
Bitumen sol. in CS <sub>2</sub> .....	60.36	90.93	99.64	94.63	10.83	8.10	99.46	11.34
Org. matter insol. in CS <sub>2</sub> .....	3.94	3.74	0	0.72	87.68	88.54	0.50	0
Inorg. or mineral matter.....	35.70	5.32	0.36	4.65	1.50	3.36	0.046	88.66
Bit. sol. in 62° naphtha.....	41.00	34.40	61.70	58.50	wt increased	2.76?	81.71	9.25
This is per cent of total bit.....	68.00	38.85	61.85	61.85	39.10	33.85	82.20	81.50
Carbenes: bit. insol. in CCl <sub>4</sub> .....	could not filter	0	0.18	1.75	1.57	1.65	2.51	1.59
Bit. more sol. in CCl <sub>4</sub> .....	....	1.37	0	0	0	0	0	0
Original loss on ignition.....	64.30	94.68	99.64	95.35	98.50	96.64	99.96	11.34
Fixed carbon.....	36.69	39.60	43.13	37.45	35.60	....	10.03	6.85
Sulfur on original.....	4.22	4.70	0.52	1.24	4.00	4.34	0.29	0.78
Specific gravity 78° F.....	1.372	1.05	1.018	1.006	1.032	1.004	0.891	2.097
Streak.....	dark brown	nearly black	brown	brown	brown	brown	brown	brown
Luster.....	dull	glossy	glossy	slightly glossy	glossy	glossy	dull	dull
Fracture.....	conchoidal	conch.	conch.	conch.	conch.	conch.	conch.	....
Hardness.....	1	<1	2	<1	1	1	<1	....
Odor.....	tarry	tarry	slightly tarry	petroleum	tarry	tarry	petroleum	slightly oily
Softens ° F.....	203	132	320	264	{ above b. p.	{	134	....
Flows ° F.....	266	181	377	275	{ mercury	{	140	....
Penetration at 78° F.....	0	30	0	0	0	0	30	0



the standard tests recommended by Richardson<sup>1</sup> and are meant primarily to determine the fitness of the materials for asphalt paving. No one of the materials as it occurs in nature comes up to the standards completely, but in the cases of Trinidad, Bermudez, rock asphalt and gilsonite the bitumen could be mixed with heavy petroleum oils and given the required penetration and other physical properties. As our work is concerned with the properties of the materials as they occur in nature no compounding was done. For the use of a standard machine for making the penetration tests we are indebted to the office of the City Engineer, Salt Lake City.

The bitumens in asphalts are divided into two general classes,<sup>2</sup> *viz.*, those soluble in 62° naphtha (malthenes) and those insoluble in carbon tetrachloride but soluble in carbon disulfide (carbenes). Our solubility tests were made by allowing one-gram samples, finely ground, to be in contact with excessive amounts of the solvents for 12 to 18 hours, filtering upon ignited asbestos in a Gooch crucible, washing with the pure solvent, drying at 100° C. and reweighing. Great difficulty was found in filtering some of the samples, especially the Trinidad asphalt.

Table II gives the ultimate composition of the samples

TABLE II

Substance	Trin.	Ber.	Gils.	Tab.	Wur. 1	Wur. 2	Ozok.	R. A.
Carbon.....	51.06	77.52	85.25	81.32	76.90	79.40	85.35	9.55
Hydrogen....	5.84	8.90	10.55	10.40	11.20	10.55	13.86	1.10
Sulfur.....	4.22	4.70	0.52	1.24	4.00	4.34	0.29	0.78
Nitrogen....	0.66	0.89	2.21	2.10	2.18	2.10	0.36	0.31
Ash.....	35.70	5.32	0.89	4.65	1.50	3.36	0.04	88.05

as determined by the ordinary combustion method, with lead chromate and copper oxide in the combustion tube. Great care must be taken in starting a combustion to prevent the too rapid distillation of the volatile components present in the samples. Nitrogen was determined by a modified Kjeldahl method, with subsequent distillation into an excess of standard sulfuric acid. Sulfur was determined by a modification of the Eschka method,<sup>3</sup> *i. e.*, roasting a weighed sample of material with zinc oxide and sodium carbonate, leaching with water, filtering, acidulating with hydrochloric acid, and precipitating and weighing barium sulfate as usual. Ash was determined by (1) reweighing the boat after a combustion, or (2) by burn-

<sup>1</sup> Richardson, *The Modern Asphalt Pavement*, 1905, 168.

<sup>2</sup> Richardson, *loc. cit.*

<sup>3</sup> Ebaugh and Sprague, *Jour. Am. Chem. Soc.*, 29, 1475 (1907).

ing a one-gram sample in a platinum dish. In two cases the ash was analyzed. The results are given in Table IIa.

TABLE IIa

Ash analysis	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	MgO
Rock asphalt.....	78.20	2.20	9.00	5.60	2.10
Tabbyite.....	35.35	2.50	9.80	29.50	9.45

Table III records the results of a series of solubility tests. The treatment with solvent lasted for 18 hours, and a motor-driven shaking device produced thorough mixture of sample and solvent. The hot extractions were made with boiling solvent in a flask fitted with a reflux condenser.

TABLE III

Solvent	Trin.	Ber.	Gils.	Tab.	Wur.	1 Ozok.	R. A.
Amyl alcohol.....	Insol.	Insol.	Inl.	4	Insol.	Insol.	Insol.
Ethyl ether.....	109	145	∞	46	Insol.	13	14
Ethyl acetate.....	30	24	{ *5 3	*7 3	Insol.	1	{ *7 4
					*5		
Amyl nitrate.....	84	39	51	Insol.	Insol.	7	16
Amyl acetate.....	132	37	86	Insol.	Insol.	1	Insol.
Benzol.....	48	36	71	35	Insol.	18	12
Toluol.....	39	33	72	57	0.09	Very sol.	14
Turpentine.....	115	116	60	65	45	Very sol.	29
Nitrobenzene.....	39	24	9	14	{ *12 Insol.	Insol.	3
Aniline.....	3	Insol.	{ *33 Insol.	Insol.	{ *2 Insol.	Insol.	Insol.
Chloroform.....	10	23	54	33	{ *1.5 0.96	∞	83
Carbon disulfide.....	∞	∞	∞	55	13.45	∞	Very sol.
Carbon tetrachloride	∞	∞	44.30	36.00	1.8	∞	12
62° Naphtha.....	Very sol.	63	5	6.80	2.8	7	18
Ethyl alcohol.....	Insol.	Insol.	Insol.	{ *1 Insol.	Insol.	Insol.	Insol.
Propyl alcohol.....	Insol.	Insol.	{ *1 Insol.	*11	Insol.	Insol.	Insol.

Numbers refer to grams soluble in 100 grams cold solvent.

\* Grams soluble in 100 grams boiling solvent.

Table IV gives the results of the fractional distillations of the hydrocarbons. A number of distillations at reduced pressure were tried, but the results were not satisfactory, and work along this line was discontinued for lack of time. It was noticed, however, that (1) gilsonite is soluble in its own distillate and in those from wurtzilite and tabbyite, (2) tabbyite is soluble in the distillates from gilsonite and wurtzilite, but (3) wurtzilite is insoluble in its own distillate and in the distillates from gilsonite and tabbyite. Gilsonite is soluble in stearin and hot paraffin, but wurtzilite is insoluble in both of these materials.

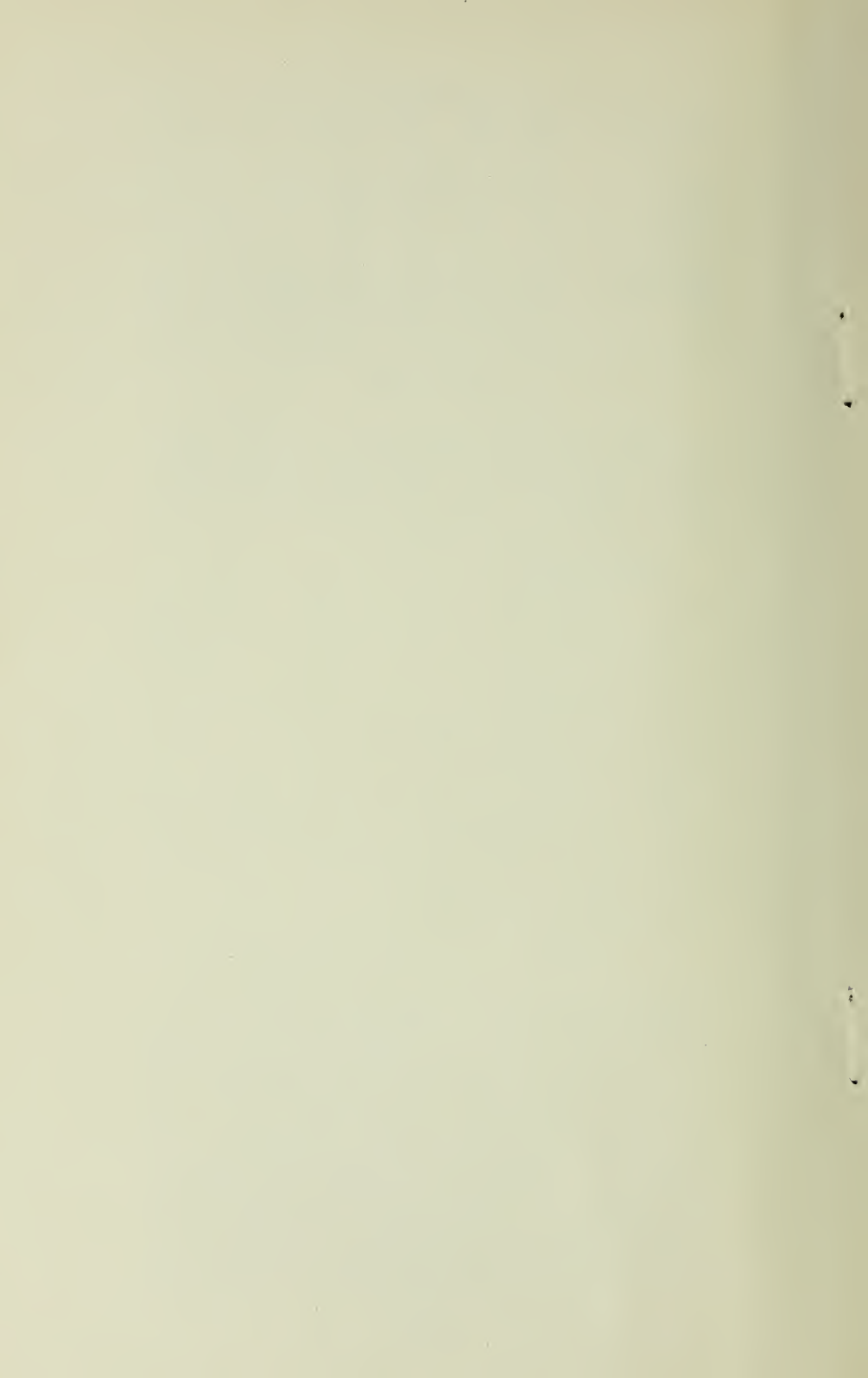
TABLE IV

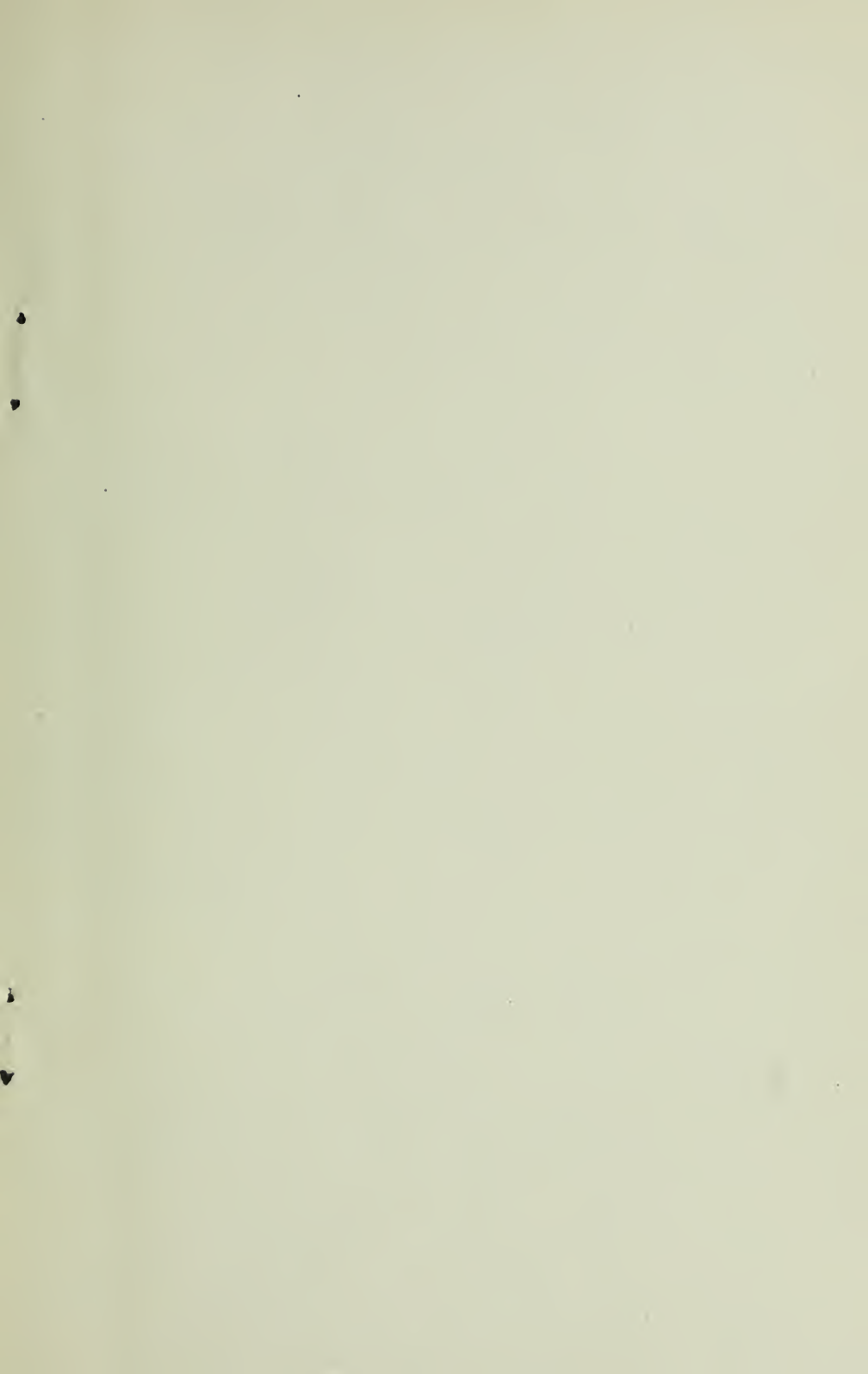
Substance	Trin.	Ber.	Gils.	Tab.	Wur. I	Ozok.	R. A.
0-150° C.....	14.93	9.89	9.34	3.12	16.15	0.21	0.91
150-200° C.....	10.42	7.99	5.34	11.93	21.70	8.91	3.22
200-250° C.....	2.26	16.08	12.84	24.87	22.82	8.38	0.29
250-300° C.....	....	21.12	28.99	13.21	0.91	17.69	....
300-350° C.....	....	....	....	4.77	....	25.89	....
350-400° C.....	....	....	....	....	....	26.85	....
Total volatile.....	27.61	55.08	56.51	57.90	61.58	87.93	4.42
Fixed carbon.....	36.69	39.60	43.13	37.45	36.92	10.03	7.53
Ash.....	35.70	5.32	0.36	4.65	1.50	0.04	88.05
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

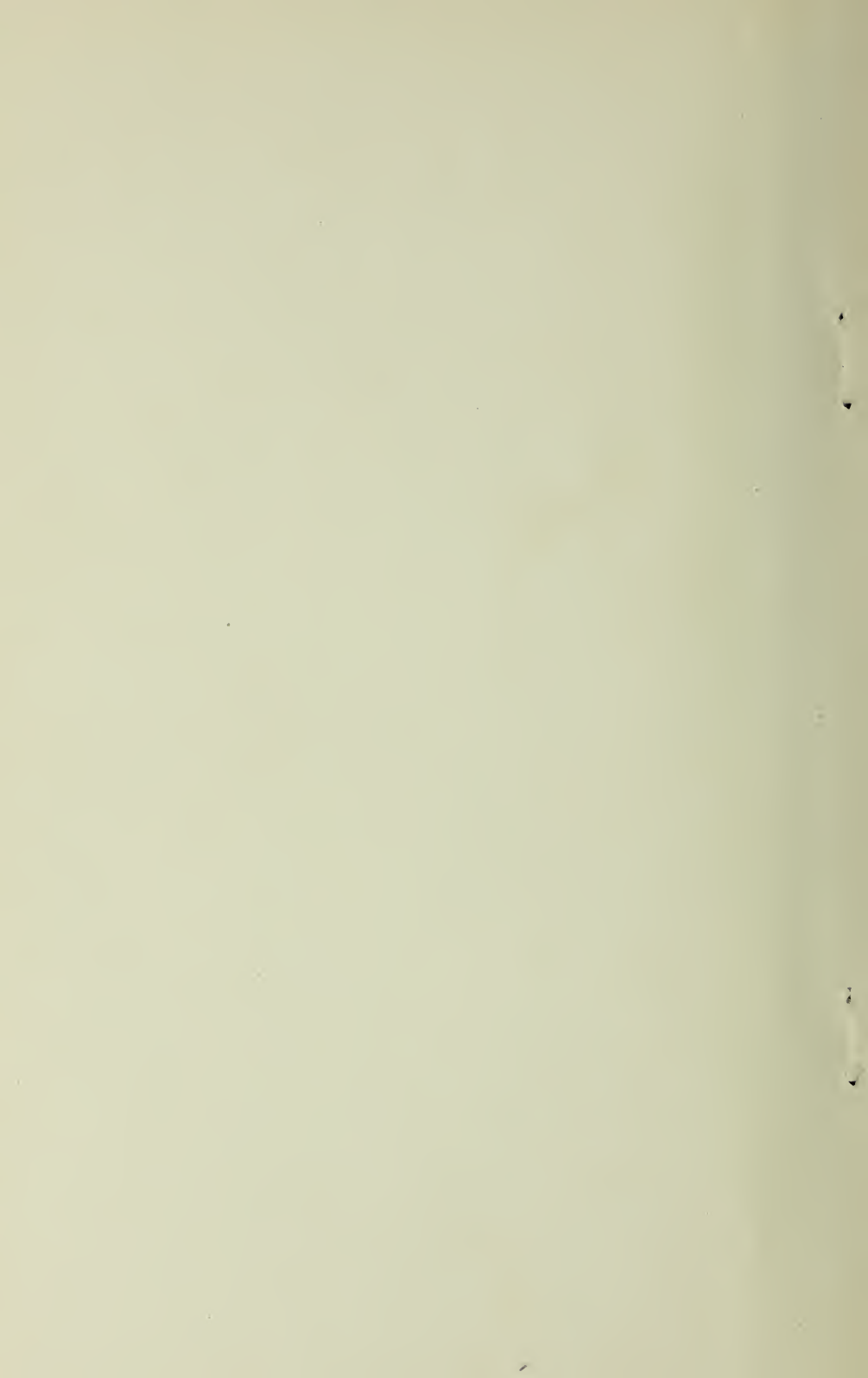
## CONCLUSIONS

The marked differences in the physical and chemical properties and in the compositions of the five hydrocarbons are established. Tabbyite is shown to be a distinct substance. The reported insolubility of wurtzilite is amply confirmed.

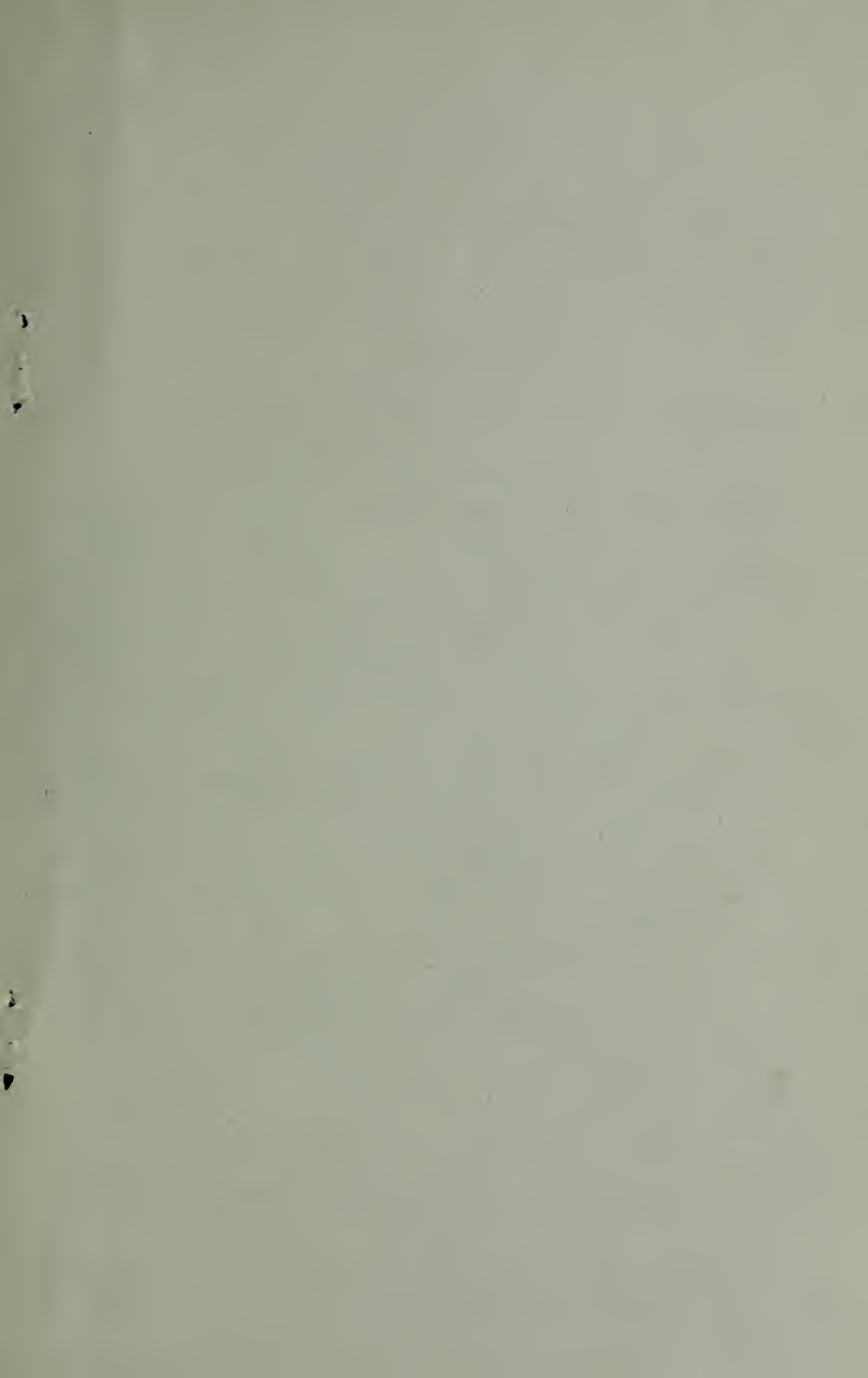
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